MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2022 / 2023 SESSION (TERM ID 2210)

DAD 5111 – FUNDAMENTALS OF ALGORITHM DESIGN

(EAI)

9 FEBRUARY 2023
2.30 p.m. – 4.30 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of 8 pages.
2. There are **TWO (2)** sections:
   - Section A: Multiple Choice Questions (10 Marks)
   - Section B: Structured Questions (30 Marks)
3. Answer **ALL** questions.
4. Please write your answers in the **Answer Booklet** provided.

SECTION A: MULTIPLE CHOICE QUESTIONS (10 MARKS)

Instructions: Choose the correct answer. Write your answer on the provided Answer Booklet.

1. Using _____ to test running time between two algorithms may be difficult as the same hardware and software environments must be used.

   A. pseudocode
   B. programming
   C. theoretical analysis
   D. experimental studies

2. What is the asymptotic running time of the following algorithm as a function of n?

```
for i←1 to n do
   for j ←1 to n do
       print "Goodbye"
```

   A. O(n)
   B. $O(n^2)$
   C. O (n log n)
   D. O (log n)

3. Assume that an algorithm with time complexity is ***O (n log n),*** takes 10 seconds to process 100 data items. What does it take to process 10,000 items?

   A. 2,000 seconds
   B. 20,000 seconds
   C. 200,000 seconds
   D. None of the above.

4. A (n) _____ is a set from which we extract elements in first-in, first-out (FIFO) order. We select elements in the same order in which they were added. Breadth First Search uses it to select which node to consider next.

   A. adjacency matrix
   B. adjacency list
   C. queue
   D. stack

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5. Apply Prim's algorithm on the graph given in Figure 1 if starting vertex is A. Choose the correct order of the MST produced.

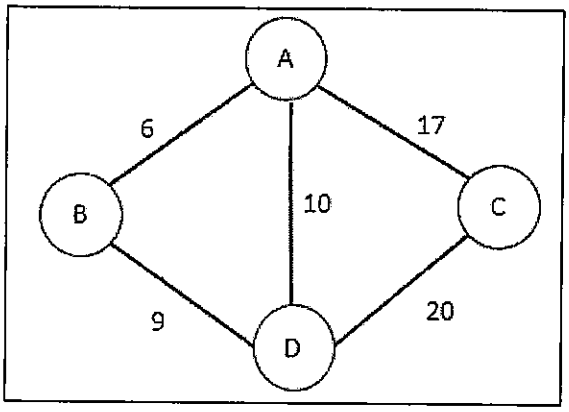

Figure 1: Undirected graph

A. A-B, B-D, A-D
B. A-B, A-D, A-C
C. A-B, B-D, A-C
D. A-D, D-B, B-A

6. _____ suggests solving each of the smaller subproblems only once and recording the results in a table form which a solution to the original problem can be obtained.

A. Divide and conquer
B. Dynamic programming
C. Greedy
D. Brute force

7. Prim's algorithm and Kruskal's algorithm are solving minimum spanning tree by applying the _____ approach in two different ways to yield an optimal solution.

A. dynamic programming
B. greedy
C. divide and conquer
D. backtracking

Continued...

8. Refer to the following table (Table 1). Based on the Fractional Knapsack algorithm using greedy technique, which item will be selected first and how much weight?

Items:	1	2	3	4	5
Weight (ml):	4	8	2	6	1
Benefit ($):	12	32	40	30	50

Table 1

A. Item 3, 2 ml
B. Item 5, 1 ml
C. Item 1, 4 ml
D. Item 2, 8 ml

9. _____ algorithm is used to find shortest path problem and it applicable to undirected or directed graphs with nonnegative weights only.

A. BFS
B. Merge sort
C. Quick sort
D. Dijkstra's

10. The _____ algorithm can be used to calculate the maximum possible traffic that can flow through a network.

A. Ford-Fulkerson
B. Dijkstra's
C. DFS
D. Gale-Shapley

Continued...

SECTION B: STRUCTURED QUESTIONS (30 MARKS)

Instructions: Answer ALL questions. Each question carries 10 marks.

QUESTION 1 (10 MARKS)

a) Provide a ***topological sorting*** using DFS based on the graph shown in Figure 2.

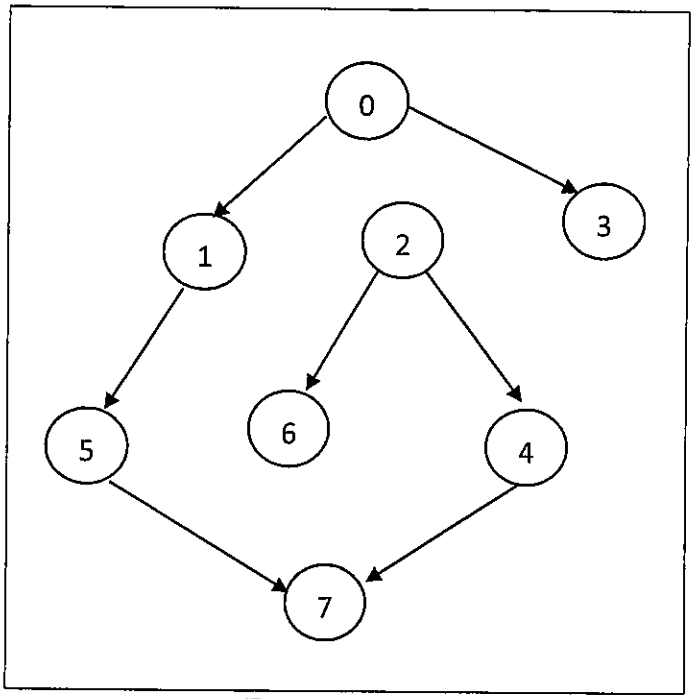

Figure 2: Directed graph

i. State your starting vertex and show your working with the use of stack and an array to store the topological ordering. (1.5 marks)

ii. Redraw the graph in linear ordering. (1 mark)

b) Perform Quick Sort on the following array. Use the last element as the pivot. Label your diagram accordingly. (2.5 marks)

33	15	8	13	4

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c) Apply dynamic programming (DP) to answer the following questions regarding the matrix chain multiplications. Given the four matrices with size:

A: 5 x 4
B: 4 x 6
C: 6 x 2
D: 2 x 7

The recursive formula:

$$m[i,j] = \min_{i \le k < j} (m[i,k] + m[k+1,j] + P_{i-1}P_kP_j)$$

i. Find the minimum number of multiplications for the matrices above. (4.25 marks)
ii. What is the optimal parenthesization order of the matrices? (0.75 marks)

[TOTAL 10 MARKS]

QUESTION 2 (10 MARKS)

a) You are given a knapsack that can carry maximum weight 7 kg. There are four items the following weights and values as shown in Table 2.

Items:	A	B	C	D
Weight (kg):	4	3	5	6
Benefit ($):	15	6	18	22

Table 2

i. Solve this problem using dynamic programming (DP) approach to find the optimal benefit of the items you can carry using the knapsack. Show your working steps using a DP table. (4.5 marks)
ii. List out the item(s) that you can carry based on your answer in (i). (0.5 marks)

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b) Consider the following *st*-flow network as shown in Figure 3, and feasible flow f from the source vertex S to the sink vertex T.

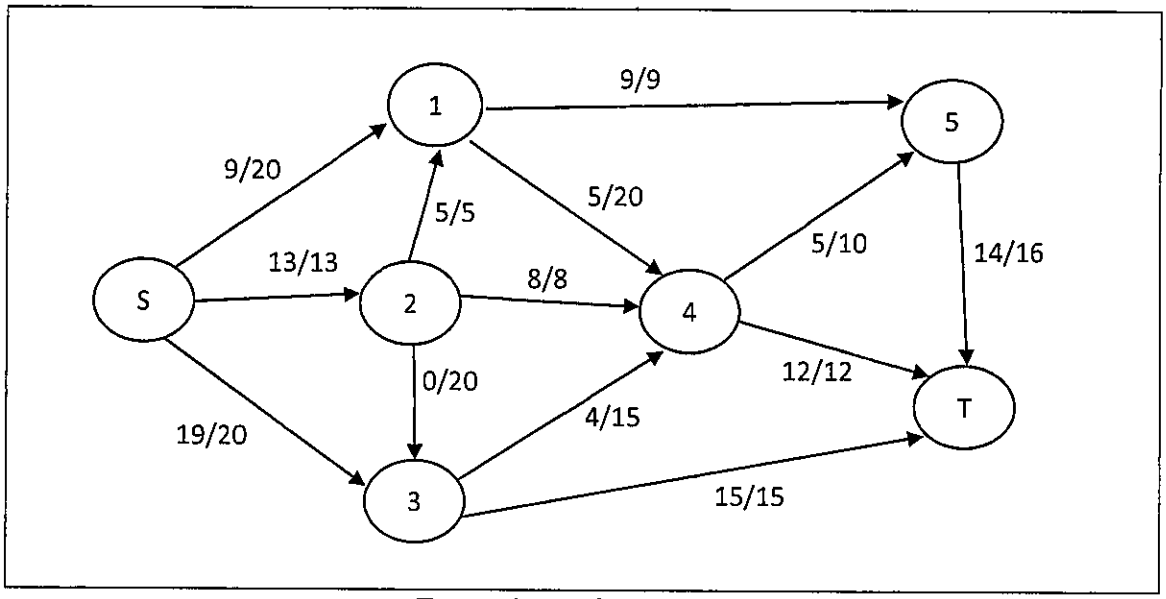

Figure 3: st-Flow Network

i. With the given flow and capacity values in the above network, what is the total value of the flow at the sink T? (2 marks)

ii. Apply Ford-Fulkerson algorithm, from S to T. on the above network. List all the possible augmenting path. Each path is represented as a sequence of vertices. (2 marks)

iii. What is the value of the maximum flow? (1 mark)

[TOTAL 10 MARKS]

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QUESTION 3 (10 MARKS)

a) Based on the graph shown in Figure 4, step through Dijkstra's algorithm to calculate the shortest paths from node A to all other nodes on the graph.

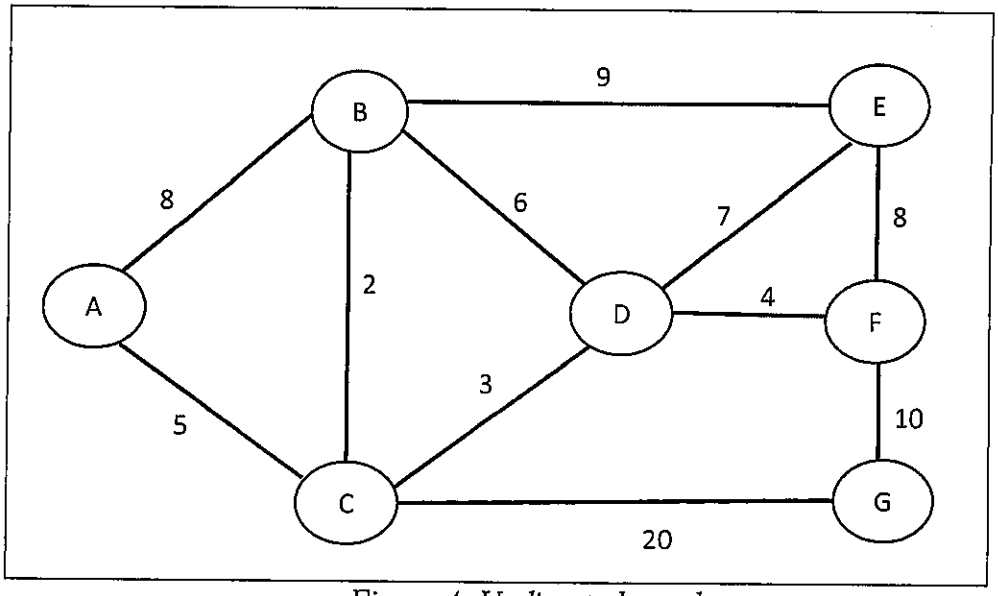

Figure 4: Undirected graph

i. Show your steps as in the table below. Cross out old values and write in new ones, from left to right within each cell, as the algorithm proceeds. (3.5 marks)

Vertex	Shortest distance from A	From
A		
B		
C		
D		
E		
F		
G		

Continued...

ii. List the vertices in the order in which you marked them visited. (0.5 marks)

iii. Indicate the lowest-cost path from node ***A*** to node ***D***. (0.5 marks)

iv. Indicate the lowest-cost path from node ***A*** to node ***G***. (0.5 marks)

b) Apply Kruskal's algorithm to find a minimum spanning tree (*MST*) for the graph as shown in Figure 5.

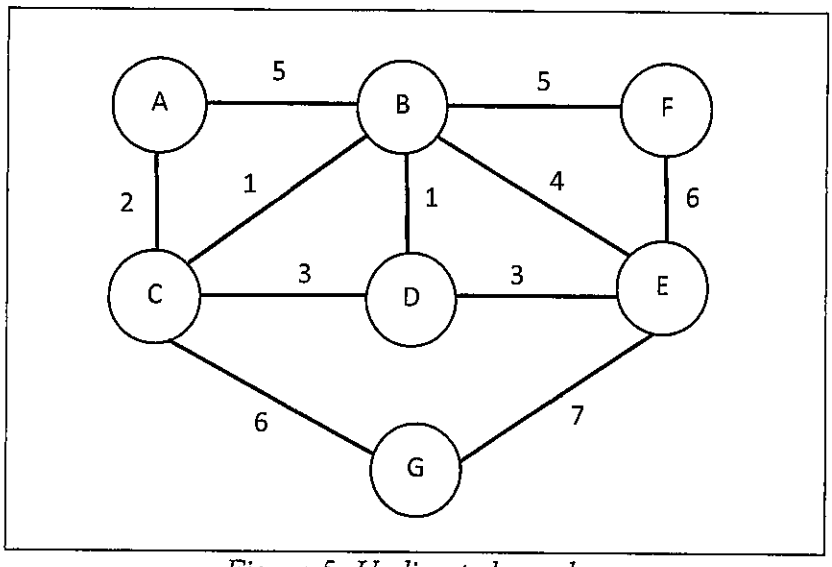

Figure 5: Undirected graph

i. Draw the MST obtained. (2 marks)

ii. Indicate the order of the edges added to the tree to obtain an MST tree. (2 marks)

iii. What is the total weight of the MST? (1 mark)

[TOTAL 10 MARKS]

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